AN ABSTRACT OF THE THESIS OF

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Title: A Comparison of Two Body Composition Tests: The 3-Site Skinfold and the 2-3-Girth Measurements

Abstract approved: Mark Stanbrough

Committee members: Dr. Mark E. Stanbrough, Chairperson
Dr. Bill Tidwell
Dr. Loren D. Tomkins

The purpose of this thesis was to determine the accuracy of the 2-3-Girth test and the 3-site Skinfolds when applied to non-weight trained males and females and to weight trained males. Underwater weighing was used as a criterion against which the 2-3-Girth and 3-site Skinfold tests were compared. The 3-site Skinfolds uses measurements of the chest, abdomen and thigh for men and triceps, ilium and thigh for women. The 2-3-Girth test uses measurements of the neck and lower abdomen for men and neck, upper abdomen and hip for women.

A Pearson correlation and a t-test were used to analyze the data with a level of significance at 0.01 (two tail). The analysis of the results indicated that the 2-3-Girth test can predict percent of fat accurately for both groups of men. The 3-site Skinfolds significantly underestimated percent of fat in both male groups. In the women the Skinfolds had accurate results, but for the Girth test the results were inconclusive since the researcher obtained a very low correlation.

A COMPARISON OF TWO BODY COMPOSITION TESTS:
THE 3-SITE SKINFOLD AND THE 2-3-GIRTH MEASUREMENTS

A Thesis

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the Division of HPER

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by

George Savourdos

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Joella H. Mehrhoff
Approved for the Major Division

Faye N. Vowell
Approved for the Graduate Council

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Chapter I

Introduction

This study evaluates and compares the accuracy of two body composition tests, the 2-3-Girth and the 3-site skinfolds. A third test, underwater weighing, was used as the criterion for the accuracy of the other two.

This chapter is devoted to a general introduction of the topic, a statement of the problem, a discussion of what the researcher did, why the study is significant and what the hypothesis is. Furthermore, in this chapter, the writer gives the assumptions of the study and some basic concepts are defined.

The Problem

Body composition is used as a guide to the evaluation of someone's health, body weight and fat (Crow, Brown, Hubbard & Copeland, 1982; Kuntzleman & Reiff, 1992). Many doctors stress that it is more important to know the percent of fat in the body, instead of how much the actual body weight is. Researchers have also emphasized the importance of body composition during weight loss diets. The more lean mass someone has in his/her body, the higher the basic metabolic rate (BMR) is, which means that the body burns more calories

(Wilmore, 1993); this is because muscle is a very active tissue, and needs thirty to fifty calories per pound per day just to stay alive (Kase, 1991). Health professionals believe that just losing pounds is not enough for good health. The percent of weight lost during the diet that comes from fat is the most significant aspect of losing weight. Dietitians have concluded that monitoring fat intake during dieting and exercising is very important in order to lose fat instead of lean body mass (Moll, 1989).

Many athletes in specific sports like boxing, wrestling need to be "fat free" and they need to know their lean body mass. Athletes in other sports also need to know what percent of their weight is fat, because fat is "dead weight" that they needlessly carry around and hinders their performance.

Many different tests measure body composition: hydrodensitometry, body potassium counting, bioelectrical impedance analysis, computed tomography, ultrasound, skinfolds, girth measurements and others (Jensen, 1992). Most of these tests have limitations because they need very expensive equipment or have less accurate results. Others, need specialized personnel to be administered, take too much time or are not very comfortable for the subjects.

One of the most accurate ways of measuring lean body mass is underwater weighing or hydrodensitometry. Most researchers agree that when underwater weighing is done correctly, it can predict, with high accuracy, the percent of fat (error of only

2-3%, Houtkooper, 1992). This is one of the reasons why, underwater weighing measurements are used as a standard in developing or testing the validity of other body composition tests (Fish, Mcgilbra, Carrol & Abadie, 1993; Kuta, Clark & Sullivan, 1993).

Limitations of underwater weighing are that it needs expensive equipment in order to be administered correctly, that the testers have to be experienced in giving this test (Houtkooper, 1992), and that lung residual volume needs to be measured not predicted otherwise, the results will not be very accurate (Wilmore, 1969). The above reasons make the underwater weighing test appropriate for lab use, but very inappropriate for every day use by teachers, coaches or health professionals, who want to test many people and do not have extensive training in the underwater test.

Two tests that do not need very expensive equipment in order to be implemented are the skinfolds and the girth measurements. Skinfold tests measure subcutaneous fat with a caliper, in order to predict the percent of fat in the body. Skinfold tests, using from 1 to 10 measurement sites, have an error factor of up to 4.8%, (Lohman, 1981). Skinfolds are one of the most common methods used today in predicting percent of body fat. Girth measurements predict percent of body fat by compartmentalizing the body into fat and fat-free divisions. The 2-3-Girth test uses a measuring tape to measure two sites for men and three for women. Hodgdon and Beckett report the error of the test is 3.7% for men and 2.7% for women (cited in Adams, 1990, p.195).

It is evident that there is a need for a body composition test which is inexpensive, accurate, and easy to administer. Skinfold measurements are commonly used by physical education teachers, coaches and health professionals in order to predict percent of body fat. Skinfold measurements though have many limitations: they need to be administered by experienced testers in order to be accurate, the testers need a lot of practice in order to become good in administering the skinfolds, and even then, there is evidence that, if a tester measures a subject at two different times the results may differ. Different testers also get different results when they test the same subject (Lohman, 1981).

The skinfold tests take a lot of time to administer because the tester, most of the time, measures each site three times in order to establish accurate measurements and there are one to ten sites, depending on the formula that will be used. Some subjects also do not feel very comfortable with the tester touching/grasping their body, when the test is administered.

The calipers can also create problems. When the inexpensive models are used, there is concern about their accuracy especially after they've been used for some time. Even the more expensive calipers need to be calibrated and checked for their accuracy after they have been used for a while (Katch & Katch, 1980).

The 2-3-Girth test does not need very experienced testers. A tester can learn very quickly the way to apply accurately the test and to have the same results each time it is used (Katch & Katch, 1980). The test does not bother the subjects as much as the skinfolds during the application and it does not take much time to administer. Girth measurements can also be used to test overweight subjects more easily than the skinfold tests. The measuring tape is always accurate (especially if it is a metal tape), and the tester doesn't need to worry about its accuracy after it's been used for some time.

Since the 2-3-Girth test has all these advantages over the skinfolds, the research has to determine how accurate it is when applied to the general college-aged population (non-weight trainers). Most anthropometric measurements have been limited to volunteers of a specific population, e.g. college-aged students or athletes. Different populations, ranging from active to sedentary or children to the aged, have unique body composition (Lohman, 1987). One such unique population, weight trainers, will be used in this study to establish the accuracy of the girth test.

Statement of the Problem

In this study, it is the researcher's intent to answer these three questions. First: is there a significant difference in accuracy between the 2-3-Girth test and the 3-site skinfold test when they are applied to the general college-aged male population?

Second: is there a significant difference in accuracy between the 2-3-Girth test and the 3-site skinfold when they are applied to the females of this group?

Third: is there a significant difference in the accuracy of the girth test when it is used on a general college-aged male sample and a special sample of weight trainers?

Statement of What Was Done

In this study the researcher administered the three body composition tests (underwater weighing, 3-site skinfolds, and 2-3-Girth) to two 20-40 member groups. One group (non-weight trainers, male and female) was drawn from the general population of lifetime fitness classes and the other group (only male) was drawn from people who are weight trainers.

The underwater weighing measurements were used as the standard against which the researcher evaluated the accuracy of the other two tests, the 2-3-Girth and the 3-site skinfolds.

The comparison was used to tell the investigator which of the two tests, the 2-3-Girth or the 3-site skinfolds, is more accurate. It also showed whether there was a difference in accuracy when these tests were applied to the two different populations.

Assumptions of the Study

This research is based on the assumption that underwater weighing is very accurate and can be used as a standard. Thus, extreme caution was taken in the administration of the test in order to get accurate measurements. Also, the residual volume was predicted, which reduces the accuracy of the underwater measurements.

Another assumption of this study was that students enrolled in lifetime fitness classes represented a sample of the general population of students on campus.

Significance of the Study

Body composition is one of the basic health aspects and is receiving greater attention as more and more physicians emphasize its importance. Educators or health professionals need an accurate, fast and inexpensive technique to measure percent of fat. Up until now, the most common method used involved the skinfolds, which are more accurate than the height-weight charts, but as the writer has mentioned before, have some limitations. This research attempts to prove that the 2-3-Girth test is accurate and that it can be used efficiently, effectively and with reliability, in predicting the percent of body fat in everyone.

This is important because by using the 2-3-Girth test, errors of inexperience or equipment accuracy are significantly reduced and the researchers also alleviate the discomfort of grasping the subjects. The girth test can be easily administered to overweight people and the testers can test more subjects, since it takes less time to use.

Definition of Terms

Body Fat Mass: All the quantity of triglyceride fat in the body.

Adipose Tissue Mass: Fat plus its supporting cellular and extracellular structures.

Body Composition: The relative percentage of fat, muscle, bone and other tissue, of which the human body is composed.

Lean Body Mass: All the fat free tissues of the body, muscles, bones, connective tissues, internal organs.

Subcutaneous Fat: The fat found underneath the skin, which represents about half of the total body fat.

Calipers: Instruments that apply a standard pinch pressure and provide an easily read measurement of the pinched skinfold.

Hydrodensitometry: Measuring the weight underwater, by applying Archimedes principle which says that when an object is in the water it is buoyed up by a force equal to the weight of the water it displaces.

General college-aged population: In this study, the researcher defines this population as male and female non-weight trained, ages 17-25.

Weight trainers: In this study are students who have participated in regular (at least 3 times/week) weight training exercises for the past two years. In this group may be included track athletes, football players, basketball players, or any student who has been lifting weights for strength/muscle buildup.

Anthropometry: (Anthropo=human, Metry=measure) A number of body measurements part of which are the body composition tests.

Girth measurements: Measurements of the circumference of body parts that result in a linear dimension such as inches. The **2- 3 Girth test** is a method that uses stature and two (men) three (women) circumference measurements to predict body density in order to calculate percent of fat.

Chapter II

Review of Literature

Why should one study body composition? There are many answers to this question as Buskirk (1987) mentions:

> As a tool in characterizing populations or specific segments of a population;
>
> As a tool in studying gender and ethnic differences;
>
> As a tool describing normal and abnormal growth, development, maturation, and aging;
>
> To follow changes in status as occur in pregnancy and lactation;
>
> To provide bases of reference for physiological variables;
>
> To identify patterns important in the characterization of metabolic or other disease, including cancer;
>
> To provide bases of reference for drug and other therapeutic administrations;
>
> As a tool in physical fitness appraisal;
>
> As a guide to athletes who are preparing for competition or engaged in competition.

All kinds of scientists can study body composition and can use it in their evaluations: nutritionists, anatomists, physical anthropologists, physiologists, physical educators, physicians, radiologists and others (Buskirk, 1987).

According to Buskirk (Round table, 1986), the desirable percentage of body fat for men and women (for good health) is between 10-25% and 18-30% respectively (Table 1). It is also expected that between the ages of 20 and 60 an individual will increase his/her body fat by 1% per decade.

Table 1

Standards of fatness for men and women in percent body fat

Classification	Men	Women
Essential fat	0-5	0-8
Minimal weight	5	15
Most Athletes	5-13	12-22
Optimal Health	10-25	18-30
Optimal fitness	12-18	16-25
Obesity	>25	>30

Note. From "Body composition: A round table" 1986, *The Physician and Sportsmedicine*, 14, p.152.

There are many ways of predicting or measuring percent of fat or lean body mass (LBM). Anthropometric measurements such as skinfolds and body circumferences (girths) are used to predict body density (D_b) by regression equations derived by comparing the results to D_b measured in underwater weighing (Lohman, 1981). Bioelectric Impedance is another way used to predict lean body mass by introducing an electrical current of very low intensity at the hands and feet. Lean body mass is predicted by measuring the resistance to that current (which travels at different speeds through lean and fat tissue). This technique tends not to be very accurate when used in lean subjects (Colville, Heyward & Sandoval, 1989; Dolgener, Hensley, Becker & Marsh, 1992). Total Body Electroconductivity, which uses radio frequencies generated by electrical energy in order to predict LBM, seems to be much more accurate (Presta et al., 1983)

Direct measurements of LBM can be done by Total Body Nitrogen, Total Body Potassium and Intracellular Water; percent of body fat can be found by Hydrodensitometry and Dual Photon Absorptiometry (DPA) or Dual Energy X-ray Absorptiometry (DEXA); adipose tissue can be measured by Computed Tomography, Magnetic Resonance Imaging and Ultrasonography; and bone or extracellular solids by Total Body Calcium (Jensen, 1992; Buskirk & Mendez, 1984).

History

As Keys and Brozek (1953) reported, work on the measurement of the body and all its parts started more than a century ago by German anatomists. The weight of the human body mass (body solids, liquids and gases) depends on the gravitational pull that the earth exerts on the mass. Weight is proportional to body volume (the amount of space the body occupies) and because tall people weigh more and have larger volumes than short people, mathematical expressions (equation 1) which enable someone to predict the weight of a person from his/her height have been formulated (Ricci, 1979, p 17):

$$(1)\ W_{kg} = 0.985\ H_{cm} - 100$$

These techniques, however are not very accurate in predicting weight unless additional factors such as age, sex or diameters, circumferences and skinfolds are used.

Hydrodensitometry (Underwater weighing, UWW) employs the Archimedean principle to measure D_b, because fat tissue has lower specific gravity than does LBM. Behnke, Feen and Welham (1942) used the Archimedean principle in order to determine the specific gravity of 99 men, enlisted in the Navy, ages 20-40. In 1945 Rathbun and Pace created a formula (equation 2) which used specific gravity[1] (SG) as a basis in order to calculate percent of body fat (cited in Rcci, 1970):

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[1] Specific gravity: the ratio of the body's density to the density of water, at specific temperatures (Keys and Brozek, 1953, p. 267

$$(2)\ \%fat=100\ \{(5.548/SG)-5.044\}$$

In 1953, Keys and Brozek revised that equation to account for measuring density under water (eq. 3) at water temperature of 37°C and considering a reference body density of 1.0629:

$$(3)\ \%fat=100\ \{(4.201/D_b)-3.813\}$$

Siri (1961) used the two component model, which relied on fat and fat free tissue, to derive an equation (4) to calculate percent of body fat from whole body density:

$$(4)\ \%Fat=(495/D_b)-450$$

This equation applies to young, white adult males and posits constant density values for fat tissue (0.900 gm/ml) and fat-free tissue (1.100 gm/ml). Individuals though vary a lot in body density, depending on age, sex, race, and activity level (ie. bodybuilders, active athletes), which creates the need for modification of Siri's equation (Lohman, 1986). For example, in one study a wrestler had D_b of more than 1.100 (<0.00% fat) and a gymnast had D_b of 1.097 (1.7% fat); both estimates cannot be true since in order to be alive, at least 2-3% of fat is needed (Buskirk, 1987). Blacks also have been found to have D_b of 1.113 (Scutte et al., 1984) which is considerably more than 1.100. Children have lower densities than adults; an adult and a child with the same percent of fat (12%) have D_b of 1.076 and 1.051 respectively. Therefore the development of valid methods to estimate body composition in children, as well as the development of fatness standards for youth, is also very important (Lohman, 1982; 1987). Lohman changed equation 4 to apply to young adult females,(equation 5) (cited in Powers & Howley, 1990, p. 385):

$$(5)\ \%Fat=(509/D_b)-465$$

To find percent of fat using the above equations it is necessary to find D_b. Density can be found from the basic equation (6):

$$(6)\ D=M/V$$

Where: M = mass (weight)

V = volume.

Underwater Weighing

In order to calculate body volume, most researchers use the most common method, UWW (Jackson, 1984). To find the V by UWW as Powers & Howley (1990, p. 385) report, the weight of the subject is measured under water (W_u) and subtracted from the weight measured in the air (W_a) divided by the water density (D_w), so equation 6 becomes (7):

$$(7)\quad D_b = \frac{W_a}{W_a - W_u/D_w} \quad \text{or} \quad D_b = \frac{W_a x D_b}{W_a - W_u}$$

Taking into consideration two other values, the volume of air in the lungs (usually residual volume, RV) and the volume of gas in the gastrointestinal track, V_{GI} (usually a constant value of 100 ml) equation 7 becomes (8)(Buskirk, 1959):

$$(8)\quad D_b = \frac{W_a - D_w}{(W_a - W_u) - (RV + V_{GI})}$$

UWW is a very accurate method for measuring D_b with an error of only 1.08%, when RV is directly measured and 2-4% when RV is predicted (males, 24% of VC, females 28% of VC) (Morrow, Jackson, Bradley & Hurtung, 1986). Lohman (1981) also reported errors of up to 2.5% with direct RV measurement. Errors in the measurement of RV are critical, since for every 100 ml of miscalculation in RV, 0.7% of body fat will be added in the final calculations (Barnes, 1987). The most accurate method for measuring RV directly is Plethysmography, but RV can also be measured by Helium Dilution, which Barnes (1987) found not to be very accurate; by the Nitrogen Washout technique (Morrow et al., 1986); or by the Oxygen-dilution technique, which was simplified by Willmore, Vodak, Parr, Girandola & Billing (1980).

UWW is a good method to use only in a laboratory setting to measure D_b, because it needs special equipment, trained personnel and a lot of time. For the above reasons scientists have tried to develop other methods that are more practical. Anthropometric measurements, such as skinfolds, girths and diameters, have been developed in order to estimate body composition.

Skinfolds

The first skinfold regression equation used to estimate body composition was developed by Brozek and keys (1951). It had high correlation (R=0.87). Most of the equations that were developed in the 1960's and 1970's were population specific (Jackson, 1984; Jackson & Pollock, 1977), which meant that they were developed from small homogeneous samples. During the last 30 years, approximately 100 prediction methods have been proposed in order to measure percent of body fat or lean body mass (Katch & Katch 1980).

Skinfolds measure subcutaneous fat (fat that lies just under the skin), which represents a variable fraction of the total body fat (ranges from 20-70%) and depends on such factors as age, sex, how much fat one carries and what measurement technique is used (Lohman, 1981). D_b estimated by the sum of skinfolds is compared to D_b determined by UWW in order to find the most accurate regression formula to predict body fat (Powers & Howley, 1990, p.386)

The most common sites used in skinfold (S) measurements are abdomen, chin, suprailium, midax, triceps, thigh, subscapular, knee, chest and biceps (Lohman, 1981).

As mentioned before, most early regression equations were population specific (ie. young white, adult, males or females). As Jackson and Pollock (1985) mention, researchers have identified three variables that affect the prediction of body density from anthropometric equations. First, subcutaneous fat is distributed differently in men and women. Second, younger subjects have higher densities than older subjects. Third, the relationship between body density and skinfold fat is nonlinear. In 1980, Jackson, Pollock and Ward and in 1978 Jackson and Pollock (Tables 2 and 3) developed generalized equations for women and men respectively, using 3, 4 (women only) and 7 sites. These equations were generalized to include accurate measurements for men ranging in age from 18 to 61 (n=403) and women from 18 to 55 (n=283) and to adjust for the nonlinearity a quadratic component was added.

Sinning and Wilson (1984) tested the validity of 9 generalized regression equations for women on athletes. The equations from Jackson et al. (1980) were the most accurate with an error of 3.27% in a sample that ranged from 10.3-34.0% fat.

Table 2

Generalized equations for predicting body density of women

Equation		R
(9) D_b=1.0970−0.00046971(X_1)+0.00000056(X_1)^2		0.852
(7-sites)	−0.00012828(X_4)	
(10) D_b=1.0960950−0.0006952(X_2)+0.0000011(X_2)^2		0.849
(4-sites)	−0.0000714(X_4)	
(11) D_b=1.0994921−0.0009929(X_3)+0.0000023(X_3)^2		0.842
(3-sites)	−0.0001392(X_4)	

Key: X_1=sum of 7 S :(chest, axilla, triceps, subscapular, abdomen, suprailium and thigh); X_2=sum 4 S (triceps, abdomen, suprailium and thigh); X_3=sum of 3 S (triceps, thigh and suprailium) X_4=age.

Note. From: "Generalized equations for predicting body density of women" by A.S. Jackson et al., 1980, Medicine and Science in Sports and Exercise, 12, p.178.

Table 3

Generalized equations for predicting body density of men

Equation	R
(12) $D_b=1.11200000-0.00043499(X_1)+0.00000055(X_1)^2$	0.902
(7-sites) $-0.00028826(X_4)$	
(13) $D_b=1.1093800-0.0008267(X_2)+0.0000016(X_2)^2$	0.905
(3-sites) $-0.0002547(X_3)$	

Key: X_1=sum of 7 S (chest, axilla, triceps, subscapular, abdomen, suprailium and thigh); X_2=sum of 3 S (chest, abdomen and thigh); X_3=age.

Note. From "Generalized equations for predicting body density of men", by A.S. Jackson and M.L. Pollock, 1978, British Journal of Nutrition, 40, p.501.

In 1985 Sinning et al. tested the validity of 21 generalized regression equations on male athletes, again Jackson's and Pollock's equations were the most accurate with errors as low as 2.38% fat. Jackson and Pollock (1985) later developed two more generalized equations (men and women, Table 4) using 3 sites, but eliminating the thigh measurements from them, since it seems to be one of the most difficult sites to measure especially in overfat subjects.

Table 4

Generalized body density equations (3-sites) for men and women without the use of the thigh

Equation	R
Men	
(14) $D_b=1.1125025-0.0013125(X_1)+0.0000055(X_1)^2$ $-0.0002440(X_3)$	0.89
Women	
(15) $D_b=1.089733-0.0009245(X_2)+0.0000025(X_2)^2$ $-0.0000979(X_3)$	0.83

Key: X_1=sum of 3 S (chest, triceps and subscapular); X_2=sum of 3 S (triceps, suprailium and abdominal); X_3= age

Note: From "Practical assessment of body composition" by A.S. Jackson and M.L. Pollock, 1985, The Physician and Sportsmedicine, 13(3), pp. 80,82.

Circumferences

In 1961, Behnke used 11 body circumferences and 8 diameters[2] to estimate LBM. Circumferences (Girths) seem to be fairly easy measures to use. The reliability of the measurements can be controlled by positioning properly the tape on the site and using the correct tension when the measurements are applied: tight enough so there is no space between the tape and the body , but not so tight that the tape "indents" the flesh (Callaway et al., 1988). Body girths have been used by themselves or in combination with other anthropometric measures (skinfolds) to estimate LBM or D_b and percent of fat. In fact, regression equations that have used both skinfolds and circumferences have shown to be very accurate with high correlations, R=0.916 men and R=0.865 women (Jackson & Pollock, 1978; Jackson et al., 1980). Katch and McArdle (1973) also reported that circumferences predicted more accurately (R=0.80) density in women than did skinfolds (R=0.77, n=69), and they were as accurate as skinfolds in predicting density in men (R=0.86, n=53).

Circumference measurements are susceptible to error when estimating body fat, especially in cases where a subject might lose fat through a diet but gain LBM through exercise. In such

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[2] Circumferences: Shoulders, Chest, Abdomen, Buttocks, Forearm, Wrist, Thigh, Knee, Calf, Chest, and Ankle. Diameters: Biacromial, Bi-iliac, Chest, Bitrochanteric, Wrists, Ankles, Knees, and Elbows.

a case the circumferences might stay the same introducing an error (Jackson & Pollock, 1976).

Hodgdon and Beckett developed a method, the 2-3 girth, which estimates percent of fat using only circumference measurements and height (Table 5). The method was developed using large numbers of Navy man and women at the Naval Health Research Center and had high correlations (R=0.90 men and R=0.85 women) when compared to under water weighing (cited in Adams, 1990, p.195).

The reliability of girth measurements is good. The upper abdomen and hip have, as reported by Malina et al., 1.31 cm and 1.23 cm intrameasurer and 1,56 cm and 1.38 cm intermeasurer error (cited in Callaway et al., 1988). Wilmore and Behnke also reported a test-retest correlation of 0.99 for the lower abdomen in men and 0.95 for the neck (cited in Callaway et al., 1988).

Table 5

2-3-Girth equations for men and women

Equation	R
Men	
(16) Circumf. value (in)=Lower Abdomen-Neck	0.90
Women	
(17) Circumf. value (in)=Upper Abdomen+Hip-Neck	0.85

Key: Using appendix A, the circumference value and the height give the percent of fat

Note: From Exercise physiology laboratory manual (p.196) by G. M. Adams, 1990, Dubuque, IA:Wm. C. Brown Publishers.

Summary

Body composition is one of the very important health related factors and there is a need for tests that accurately measure or predict the fat percentage in the body. The anthropometric measurements (skinfolds, girths and diameters) that have evolved the past few years have answered that need. Tests like the skinfolds have been used for years with good and reliable results, but have also faced problems. The discomfort of grasping the skinfold and the difficulty of accurately taking skinfolds from some sites (ie. abdomen, thigh) or locating the precise location of some others created the need for an alternative. This alternative could be the girth measurements, which can be less invasive, easier to learn and faster to administer.

Chapter III

Methods and Procedures

Introduction

This study involves a comparison of the accuracy of two body composition tests, the 2-3-Girth test and the 3-site skinfolds. The tests were administered to two groups: group one represented college students in general(non-weight trained) and group two represented active[3] weight trainers. The results of the two previous tests were then compared to values established from underwater weighing, which was used as the criterion in comparing the accuracy of the other two (2-3-Girth, 3-site skinfold) body composition tests.

Database

Target Population

The target population for this study was male and female college-aged (17-25, non-weight trained) students for one group and male college-aged weight trainers for the other group. The accessible population were students enrolled at Emporia State University. More specifically, the first group

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[3] Athletes involved in regular weightlifting for muscle buildup at least the past two years.

was selected from activity classes and the second group from students who train with weights regularly, including track athletes and football players.

Sampling Procedures

There are two groups in this study. Group one representing the general college population was drawn from students participating in lifetime fitness classes (LFc). This was a convenience sample, but the researcher tried to make the selection of the subjects as random as possible. Approximately 40 subjects (male and female) were randomly selected from all the volunteers. All the volunteers were assigned a number and the subjects were drawn using a table of random numbers. The students were motivated to participate in the study with extra credit points for their LFc.

Group two, representing the weight trainers, was drawn from students who frequent the weight-room of the recreational facilities and from varsity teams. The requirements for participating in this group were first, being male and second, having at least two years of regular weight training experience. In this group, 17 subjects participated. The mean weight of this group was about 16 Kg more than the non weight trained group (due to weight training, muscle build up) which can show the difference in the body type of the two groups. In both groups, the age limitation was 17-25. Table 6 gives the detailed physical characteristics of the two groups.

All subject had to sign an informed consent document (see Appendix A), which provided the subjects with all the details of the study and what the research is trying to accomplish. It also explained any "discomfort" that the subjects might face during the testing. All the measurements were recorded on the data form (Appendix B).

Table 6

Physical characteristics of the two groups

Group 1 (general population)

Males n=22	Mean	S	Range
Age	20.10	1.85	17-24
Wt_{kg}	78.23	14.16	54-105
Ht_{cm}	178.14	8.04	157-188

Females n=20			
Age	19.65	1.95	18-25
Wt_{kg}	57.15	6.61	41-71
Ht_{cm}	162.80	4.16	156-169

Group 2 (weight trainers)

Males n=17	Mean	S	Range
Age	20.24	1.57	18-22
Wt_{kg}	94.24	11.60	78-120
Ht_{cm}	182.29	5.98	174-197

Research Methodology and Design

The study evaluated the effectiveness of two tests by comparing their results to values obtained by a third test, which was used as the criterion. This study was looking for evidence of criterion-related concurrent validity, because the tests were administered at the same time.

Table 7

Design For a Criterion-Related Study

	Criterion	Observations	
Subjects	C	O_1	O_2
A	-	-	-
B	-	-	-
C	-	-	-
D	-	-	-
E	-	-	-
F	-	-	-
G	-	-	-
etc.			

The results of O_1 (Table 7) were evaluated for accuracy against the criterion using a correlation coefficient (r), and then the results of O_2 were evaluated the same way. A *t*-test was also used in order to evaluate the difference in the accuracy of the tests when used on the two different populations and when used on males and females. The mean, the standard deviation and the range were also reported for all the data.

Statistical Design

Statistical techniques

In this study, the researcher used a correlation coefficient (r) to compare the data. First, the researcher correlated the results of the skinfolds (S) to the results of the underwater test (W), r_{SU}, then the results of the girths (G) to the underwater test, r_{GU}. For the weight trainers group, the researcher correlated the results in the same way.

The investigator also ran a t-test with the scores of the two groups (males vs females and weight trainers vs non-weight trainers), in order to find if there is a significant difference or not. The level of significance was α=.01.

Statement of the hypothesis (Null Form).

The first hypothesis is

> There is not a significant difference in the accuracy of the 2-3-Girth test and the 3-site Skinfold test when compared to hydrostatic weighing and applied on male non-weight trainers.

Stated symbolically the null hypothesis is

H_o: $\mu_{Um} = \mu_{Sm}$

H_o: $\mu_{Um} = \mu_{Gm}$

The alternative hypothesis is

H_a: $\mu_{Um} \neq \mu_{Sm}$

H_a: $\mu_{Um} \neq \mu_{Gm}$

The second hypothesis is

There is not a significant difference in the accuracy of the 2-3-Girth and the 3-site skinfold test when they are used on females.

Stated symbolically the null hypothesis is

H_o: $\mu_{Uf} = \mu_{Sf}$

H_o: $\mu_{Uf} = \mu_{Gf}$

The alternative hypothesis is

H_a: $\mu_{Uf} \neq \mu_{Gf}$

H_a: $\mu_{Uf} \neq \mu_{Gf}$

The third hypothesis is

There is not a significant difference in the accuracy of the 2-3-Girth and the 3-site skinfold test when it is used on the two different populations of college non-weight trainers and weight trainers.

Stated symbolically the null hypothesis is

$$H_o: \mu_{Uw} = \mu_{Sw}$$

$$H_o: \mu_{Uw} = \mu_{Gw}$$

The alternative hypothesis is

$$H_a: \mu_{Un} \neq \mu_{Gn}$$

$$H_a: \mu_{Uw} \neq \mu_{Gw}$$

The correlation coefficient is the best method to use in a criterion-related validity study, in order to find the relationship that exists between the scores a subject obtains on two instruments. The t-test can indicate if the difference in the means is significant.

External validity

It is very difficult to draw a random sample for this study. The researcher though believes that the external validity of the study was not completely compromised by using volunteers, because a random sample was selected from all the students who agreed to participate in the study.

Procedures

In this study, three body composition tests were used: underwater weighing, the 2-3-Girth test, and the 3-site skinfolds. All the tests were administered in the same day, and the subjects were advised to avoid eating or drinking anything at least three hours prior to the tests.

The weight, height and VC were taken first and then the skinfolds and girth measurements. The underwater testing was administered last. After all the measurements had been completed from all the subjects, the researcher calculated the percent of body fat for each subject.

Description and Application of the Instruments

Underwater weighing procedures

Equipment: scale, water tank, water thermometer, chair, nylon ropes (Appendix C)

A Collins spirometer to measure Vital Capacity (Appendix D)

Method:

The researcher had the subject put on a swimsuit, get in the water, eliminate the trapped air that might be in the swimsuit and wet his/her hair. Then the subject sat on the chair, hanging from the scale, and was asked not to touch any part of the tank with his/her body. The tester then asked the subject to submerge him/herself totally under the water, blow all the air out of his/her lungs, stay under the water for a few seconds, so the researcher can read the scale and then to come up. This procedure was repeated 4-5 times and the average of all the trials was taken as the underwater weight. The researcher then subtracted from the average water weight the tare weight (weight of the chair, ropes and any additional weight that hangs on the scale) and this was the actual underwater weight.

Some other helpful points for accurate results in underwater weighing that were taken were the following: subjects took all jewelry off prior to the test; the subjects were not tested within 3 hours of eating or more than 12 hours from eating and, if possible, they were asked to urinate and defecate before the test (Adams, 1990).

To find the density of the water, the investigator recorded the water temperature at the time of the test and looked at the water temperature/water density chart (see Appendix E).

Vital capacity procedure

To measure the VC the subjects had to inhale and exhale maximally into a Collins spirometer.

The researcher had the subject sit in front of the spirometer, plug the nose with a nose clip and put the mouth over the breathing tube. Then the subject was instructed to inhale and exhale maximally. This was repeated twice for a more accurate reading. RV was estimated by multiplying the VC_{BTPS} by 0.24 for men and 0.28 for women (Morrow et al., 1986).

To find body density the investigator used equation 8

$D_b = BWt_a \times D_w / (BWt_a - BWt_w) - (RV + 100\ ml)$ (Buskirk, 1959)

And to find the percent of fat Siri's equation was used:

$\%fat=495/D_b-450$

D_b= Body Density

BWt_a= Body Weight in air

D_w= Water Density

BWt_w= Body Weight in water

RV= Residual Volume

2-3 Girth measurements procedure

The 2-3 Girth test was developed by the Naval Health Research Center.

Equipment: A metal tape measure (IRWIN comet, 15m)

Method:

For men two measurements were needed: 1. Neck girth (measure just inferior to the larynx, 2. Lower abdominal girth (measure at the level of the umbilicus).

For women three measurements were needed: 1. Neck girth (just inferior to the larynx), 2. Upper abdominal girth (at the level of minimal abdominal width, about midway between the xiphoid process and the umbilical), 3. Hip girth (at the level of the greatest protrusion of the gluteal muscles).

Men: circumference value (in)= Lower abd.- neck.

Women: Circumference value (in)= Upper abd.+ hip - neck.

To find the percent of fat, the researcher took the height of the subjects and looked at the height/circumference charts for men or women (Adams, 1990, chap. 21) (Appendix F).

For more accurate results, there was no space between the tape and the skin during the application of the measurement. On the other hand, the tape was not pulled so tightly as to make an indentation on the skin.

Skinfolds measurements procedures

Equipment: Lange caliper, metric tape, body marker.

Method: The tape measure was used to locate the precise site of some skinfolds (e.g. thigh, triceps) and mark the midpoint with the marker. Each site was taken three times (all the sites were taken once and then the researcher started at the beginning again and took all the sites two more times). The sum of the averages, from each site, was then used to predict body density.

For men sum of three skinfolds

(sum of three)				(Av. of 3)
1. chest	-	-	-	-
2. thigh	-	-	-	-
3. abdomen	-	-	-	-
				Sum --------

For women sum of three skinfolds

(sum of three)				(Av. of 3)
1. thigh	-	-	-	-
2. ilium	-	-	-	-
3. triceps	-	-	-	-
				Sum ---------

The caliper was held on the right hand and the examiner used the thumb and the index finger of the left hand to "grasp" the skinfold at a distance of about 1 cm above the skinfold site (or mark).

Procedures the researcher used to take the skinfolds (Jackson & Pollock, 1985):

Chest- took the fold with its long axis directed to the nipple, approximately one inch from the axillary line towards the nipple.

Abdomen- took a vertical fold approximately one inch to the right of the umbilicus.

Thigh- took a vertical fold on the front of the thigh, midway between the hip and the nearest border of the knee cap.

Triceps- took a vertical fold on the rear midline of the upper arm, half way between the top of the shoulder and the elbow.

Ilium- took a diagonal fold above the crest of the ilium at about the mid-axillary line.

To find body density, the sum of all the averages was used in equation 11 (women) and 13 (men) (Jackson et al.,1980; Jackson & Pollock, 1978):

(Women) $D_b = 1.0994921 - 0.0009929(x_1) + 0.0000023(x_1)^2 - 0.0001392(X_3)$

(Men) $D_b = 1.1093800 - 0.0008267(x_2) + 0.0000016(x_2)^2 - 0.0002547(x_3)$

Where: X_1 = Sum of triceps, ilium and thigh

X_2 = Sum of chest, abdomen and thigh

X_3 = Age

% fat= $495/D_b-450$ (Siri)

Validity and reliability

The validity of underwater weighing has been established in the literature review (Morrow et al.,1986; Lohman, 1981). For the administration of the test, in this study the researcher had to deal with the RV measurements that threaten the validity (Barnes, 1987). The RV was estimated instead of measured from the VC (because of luck of the proper equipment) by multiplying the VC_{BTPS} by 0.24 for men and 0.28 for women (Morrow, et al., 1986).

The reliability of the skinfolds is questioned in the literature (Lohman, 1981). To minimize this threat the researcher took each site three times. If any of the three measurements was more than one centimeter different from the others the measurements were taken again.

The reliability of all the tests is high when the proper procedures are followed. To make sure of that, the researcher followed the checklists for the proper administration of the tests, that were previously mentioned.

Summary

This study investigates the accuracy of two body composition tests. Accurate measurements of the percent of fat is very important for athlete's performance as well as the health of the inactive people.

The two tests that were evaluated in this study are the 3-site skinfolds and the 2-3-Girth test. Three basic questions were asked in this research. First, which body composition test is more accurate when tested on college-aged students; second, is the Girth test as accurate when applied to men as when it is applied to women; and finally, is the Girth test accurate when applied to muscular individuals?

The results of the study were statistically analyzed using the correlation coefficient, which indicates the degree of relationship between the scores a subject obtains on two different instruments and a t-test in order to see if the difference in accuracy is significant.

Chapter IV

Analysis of Data

Introduction

In this chapter the researcher discusses the statistical analysis of the results of the two groups. The questions that this research answers are as follows: is the 2-3-Girth test (G) more accurate than the 3-site skinfolds (S) when administered first, to males and second, to females of group 1 (non-weight trainers)? Is the 2-3-Girth test accurate when it is administered to the weight trained males of group 2?

The researcher used underwater weighing (U) as a standard for the evaluation of the S and G. A correlation (r) and a *t*-test were used to establish the accuracy of the tests. The level of significance for the correlations depended on the **n** (df=n-1) of each group tested. The significance of the *t*-tests was set at 0.01 (two tailed). The investigator used the statistical tables in E.W. Minium's (1978) book to find the levels of significance and t_{crit} for each test. The raw data for the two groups are presented in Appendix G.

Findings of Group 1 (Non-weight Trained)

In Table 8 the statistical results of group 1 are reported. This group was divided in two subgroups, males (n=22) and females (n=20).

Table 8

Statistical results of group 1 (non-weight trained)

Men n=22	% FAT			D_b		
	U	S	G	U	S	G
Mean	18.6	12.8	16.5	1.056	1.070	1.061
St D	6.5	6.6	6.7	0.01436	0.01516	0.01504
Range	10-31					
	$r_{US}=0.86$			$r_{UG}=0.83$		
	$t_{US}=-7.864$			$t_{UG}=-2.599$		

Women n=20	% FAT			D_b		
	U	S	G	U	S	G
Mean	25.3	24.2	24.5	1.041	1.044	1.043
St D	3.4	4.6	3.9	0.00754	0.0102	0.00854
Range	16.5-32.4					
	$r_{US}=0.59$			$r_{UG}=0.38$		
	$t_{US}=-1.265$			$t_{UG}=-0.867$		

Significance set at $\alpha=.01$ (two tailed) $t_{crit}=2.831$(men) $t_{crit}=2.861$ (women)

The two questions this research answers are which of the two tests, S or G, is more accurate when used on males and which of the two tests, S or G, is more accurate when applied to females.

For the males of this group, the correlations of both tests to underwater weighing were very high. The skinfolds had a correlation of $r_{US}=0.86$ and the girths had $r_{UG}=0.83$. The level of significance for the particular sample was 0.526. The _t_-test analysis though did not have the same results. With df at 21 and $t_{crit}=2.831$, the analysis came out with a $t_{US}=-7.864$ for the skinfolds and for the girths a $t_{UG}=-2.599$, which means that the researcher can accept the hypothesis H_o: $\mu_U=\mu_G$, but reject the hypothesis H_o: $\mu_U=\mu_S$. This result can be attributed to the difference of the means between the underwater weighing and the skinfold test (almost 6%).

The correlations of the scores for the two tests that were applied to the females of group 1 were much lower than those of the men. When the investigator correlated the results of the skinfold test to underwater weighing, the r_{US} was 0.59 and the girths had a correlation of only 0.38. The level of significance for this sample was at 0.549 and it is evident that the level of significance for the girths were much lower.

When the _t_-tests were run through (df=19, $t_{crit}=2.861$) both hypotheses, H_o: $\mu_U=\mu_S$ and $\mu_U=\mu_G$, were accepted because the _t_'s the investigator obtained were -1.265 and -0.867 for the skinfolds and girths respectively.

The difficulty of the correlation to show significance might be related to the small number of subjects that participated in the study as well as to the inconsistency of the results of the two tests, when compared to the underwater results. The raw data show clearly that the skinfolds and girths overestimated and underestimated the percent of fat compared to underwater weighing.

Findings of Group 2 (Weight Trained)

Table 9 has a summary of the mean and standard deviation of percent of fat and body density (D_b) as well as correlations and *t*-tests of group 2.

Table 9

Statistical results of group 2 (weight trained)

Men n=17	% FAT			D_b		
	U	S	G	U	S	G
Mean	15.8	10.4	16.7	1.063	1.075	1.061
St D	5.5	4.6	4.9	0.01235	0.01078	0.01122
Range	7.1-27.8					
	r_{US}=0.81			r_{UG}=0.74		
	t_{US}=-6.796			t_{UG}= 0.988		

Significance set at α=.01 (two tailed) t_{crit}=2.921

In this group 17 subjects participated. Both tests, S and G, had high correlations, r_{US}=0.81 and r_{UG}=0.74, when compared to underwater weighing (level of significance was 0.590). The t-test (df=16, t_{crit}=2.921) of this group leads the researcher to reject the hypothesis H_o: $\mu_U=\mu_S$ because the t that was obtained was too high (t_{US}=-6.796); on the other hand, the hypothesis H_o: $\mu_U=\mu_G$ is accepted, because the t obtained was t_{UG}=0.988.

Summary

The correlation proved not to be a very accurate way to show significance in this study, which is probably connected to the small number of participants.

The 3-site Skinfolds had correlations of r=0.86 and r=0.81 for non-weight trained and weight trained males, which is close to correlations obtained by other studies (r=0.91, Jackson & Pollock, 1985). The correlation that the women obtained, r=0.59, even though significant, is much lower than what is reported in the literature (r=0.84, Jackson & Pollock, 1985).

The 2-3-Girth test had high correlations for men also, r=0.83 non-weight trained and r=0.74 weight trained, but still the correlations were a little lower than that obtained by Hodgdon and Beckett (r=0.90) in the original study (cited in Adams, 1990); moreover the correlation for the women's sample in this study was significantly lower, r=0.38, than Hodgdon's and Beckett's, r=0.85.

The t-tests in this study lead the investigator to accept the three main hypothesis of this study. First, H_o: $\mu_{Um}=\mu_{Gm}$ (t_{crit}=2.831, t_{obt}=-2.599), which means that the 2-3-Girth test can predict percent of fat with significant accuracy for non-weight trained men. Second, H_o: $\mu_{Uf}=\mu_{Gf}$ (t_{crit}=2.861, t_{obt}=-0.867), which means that the 2-3-Girth test can predict percent of fat with significant accuracy for women. And third, H_o: $\mu_{Um}=\mu_{Gm}$ (t_{crit}=2.921, t_{obt}=0.988), which means that the 2-3-Girth test can predict percent of fat with significant accuracy for weight trained men.

The t-test results for the skinfolds lead the writer to reject both hypotheses concerning the males in this study. The non-weight trained males (H_o: $\mu_{Um}=\mu_{Sm}$) obtained a t of -7.864 (t_{crit}=2.831), and the weight trained males obtained a t of -6.796 (t_{crit}=2.921). This is supported also by the large difference of the mean values of the percent of fat that was obtained using the underwater test and the skinfolds.

The skinfold hypothesis is accepted only in the females of group 1, H_o: $\mu_{Uf}=\mu_{Sf}$ (t_{obt}=-1.265, t_{crit}=2.861).

Chapter V

Introduction

In this chapter the writer gives a summary of the whole study, discusses the results, and reports on the conclusions of the study. The researcher gives also some recommendations and suggestions.

Summary

Body composition is one of the health related aspects of fitness; it is important for good health and performance not only for the athletes, but also for the average person.

Many kinds of scientists use body composition results in their evaluations. Physicians, anatomists, physiologists, coaches, physical educators and others use body composition as one of the main aspects of the evaluation of subjects.

The importance of body composition creates a need for an easy to use and inexpensive way to measure percent of fat. Underwater weighing is an accurate way of measuring percent of fat, but limited to lab use. Skinfolds and circumferences have emerged as two easy, non-expensive ways to measure percent of fat. This study evaluated the accuracy of the 3-site Skinfold and 2-3-Girth tests by comparing them to underwater weighing.

The evaluation of the tests was performed on two different samples, first on college-aged non-weight trained males and females and second on weight trained males. Forty two subjects participated in the non-weight trained group and 17 subjects participated in the weight trained group. The skinfold test was administered first, taking three sites, chest, abdomen and thigh for men and triceps, ilium and thigh for women. The girth test was administered second and measured the neck and lower abdomen for men and the neck, upper abdomen and hip for women. Last the subjects were weighed underwater. The residual volume was predicted from measurements of the vital capacity measured by a Collins spirometer (.24xVC M., .28xVC F.). All the calculations to find percent of fat were done by hand at the end of the testing. The application of the tests is described in chapter 3. The results were analyzed by a correlation coefficient and a t-test at a level of significance $\alpha=0.01$ (two tail)

Discussion

This research tried to answer three questions. First is there a significant difference in the accuracy of the 2-3-Girth test and the 3-site skinfolds, when they are applied to non-weight trained sample of males, and is there a significant difference in the accuracy of those tests when they are applied to females? The final question of the study was, whether a significant difference in the accuracy of the 2-3-

Girth test exists when it is applied to weight trained males?

The statistical analysis of the results supports the hypothesis about the accuracy of the 2-3-Girth test (see Table 10).

Table 10

Hypothesis (null form) of the study

1.	H_o: $\mu_{Um}=\mu_{Gm}$	$t_{obt}=-2.599$	Accept
	H_o: $\mu_{Um}=\mu_{Sm}$	$t_{obt}=-7.864$	Reject
	$t_{crit}=2.831$		
2.	H_o: $\mu_{Uf}=\mu_{Gf}$	$t_{obt}=-0.867$	Accept
	H_o: $\mu_{Uf}=\mu_{Sf}$	$t_{obt}=-1.265$	Accept
	$t_{crit}=2.861$		
3.	H_o: $\mu_{Um}=\mu_{Gm}$	$t_{obt}=0.988$	Accept
	H_o: $\mu_{Um}=\mu_{Sm}$	$t_{obt}=-6.796$	Reject
	$t_{crit}=2.921$		

As is evident in Table 10, in the first hypothesis (males, non-weight trained) the study accepts the 2-3-Girth test as having significant accuracy, but rejects the 3-site skinfolds. In the second hypothesis (females), the study accepts both tests as accurate, and finally in the third hypothesis (weight trained males) the study accepts only the 2-3-Girth test as accurate.

The correlations that were used in this study were not as reliable in establishing significance due to the small number of participants. Despite that fact, the results of both tests (S and G) of the two male groups had significantly high correlations to underwater weighing, (S, r=0.86 and 0.81; G, r=0.83 and 0.74 non-weight trained and weight trained respectively).

Conclusions

After the statistical analysis of the results the researcher concluded that the 2-3-Girth test can be used effectively and with significant accuracy in predicting percent of fat in all three samples (males, weight trained or not and females); see table 10 for t-test results. Furthermore, the results of this study would have been more conclusive if the number of the samples were larger (at least 50) in order to make generalization for the respective populations and get better correlation results.

Another conclusion of this study was that the 3-site skinfold test seriously underestimated percent of fat in both male samples; this fact indicates that this test may not be the best test to use in samples that have similar characteristics as those used in this study. Only in the female sample did the 3-site skinfolds have acceptable results.

Recommendations

After reviewing the results the investigator of the study recommends that the accuracy of the 2-3-Girth test should be investigated further in more specific populations: for example, very lean and muscular individuals (< 12% fat). As the raw data show, out of 5 individuals with < 12% fat, four had overestimated values.

A second recommendation would be a study targeting the women. In this research, the correlation that was obtained was too low and even though the t-test showed that the results were significant, the investigator cannot make a conclusive statement for the accuracy of the 2-3-Girth test.

Another recommendation is that the RV should be measured in the hydrostatic test instead of estimated, as this study did due to lack of equipment.

Suggestions

Based on the results of this study, the 2-3-Girth test is recommended as a test that can accurately predict percent of fat in males who fall within the limits of this study.

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APPENDIX A

INFORMED CONSENT FORM

INFORMED CONSENT FORM

The Department/Division of HPER supports the practice of protection for human subjects participating in research and related activities. The following information is provided so that you can decide whether you wish to participate in the present study. You should be aware that even if you agree to participate, you are free to withdraw at any time, and that if you do withdraw from the study, you will not be subjected to reprimand or any other form of reproach.

1. Procedures to be followed in the study, as well as identification of any procedures which are experimental.

Group one and two will be tested with three body composition tests; the 2-3-girth, the 3-site skinfold and the underwater weighing test. The Girth test takes measurements with an inch tape (neck, abdomen and hip). The Skinfold test measures folds of skin, held by the fingers, with a caliper (triceps, abdomen, thigh, chest and ilium). In the underwater test the subject has to have a swimsuit on and submerge underwater for 5-8 seconds. Usually it takes 4-5 trials. The water tank is 4x4x4' and the water temperature will be between 92-98 degrees F.

2. **Description of any attendant discomforts or other forms of risk involved for subjects taking part in the study.**

Each subject will be tested individually. All tests will be explained and extreme caution will be taken during the application of the tests as to not bring any discomfort to the subjects. The discomfort the subjects might face will be the grasping during the skinfold application and going under water and exhaling during the underwater test.

3. **Description of benefits to be expected from the study or research.**

Each subject will have the opportunity to have a very accurate estimation of their body fat percentage.

"I have read the above statement and have been fully advised of the procedures to be used in this project. I have been given sufficient opportunity to ask any questions I had concerning the procedures and possible risks involved. I understand the potential risks involved and i assume them voluntarily. I likewise understand that I can withdraw from the study at any time without being subjected to reproach."

______________________________________ ____________

Subject and/or authorized representative Date

APPENDIX B

DATA FORM

NAME: ____

AGE: _____ HEIGHT: ______/______ WEIGHT: ________

GENDER: ______

....

GIRTH TEST

MEN: LOW. ABDOMEN: __________ WOMEN: UP. ABDOMEN: ________

NECK: __________ HIP: __________

NECK: __________

....

SKINFOLDS

MEN:				AV	WOMEN:				AV
CHEST:	___	___	___	___	TRICEPS:	___	___	___	___
ABDOMEN:	___	___	___	___	ILIUM:	___	___	___	___
THIGH:	___	___	___	___	THIGH:	___	___	___	___
			SUM	___				SUM	___

....

HYDROSTATIC WEIGHING

RV: _____ (BTPS) ______

TARE Wt: _______

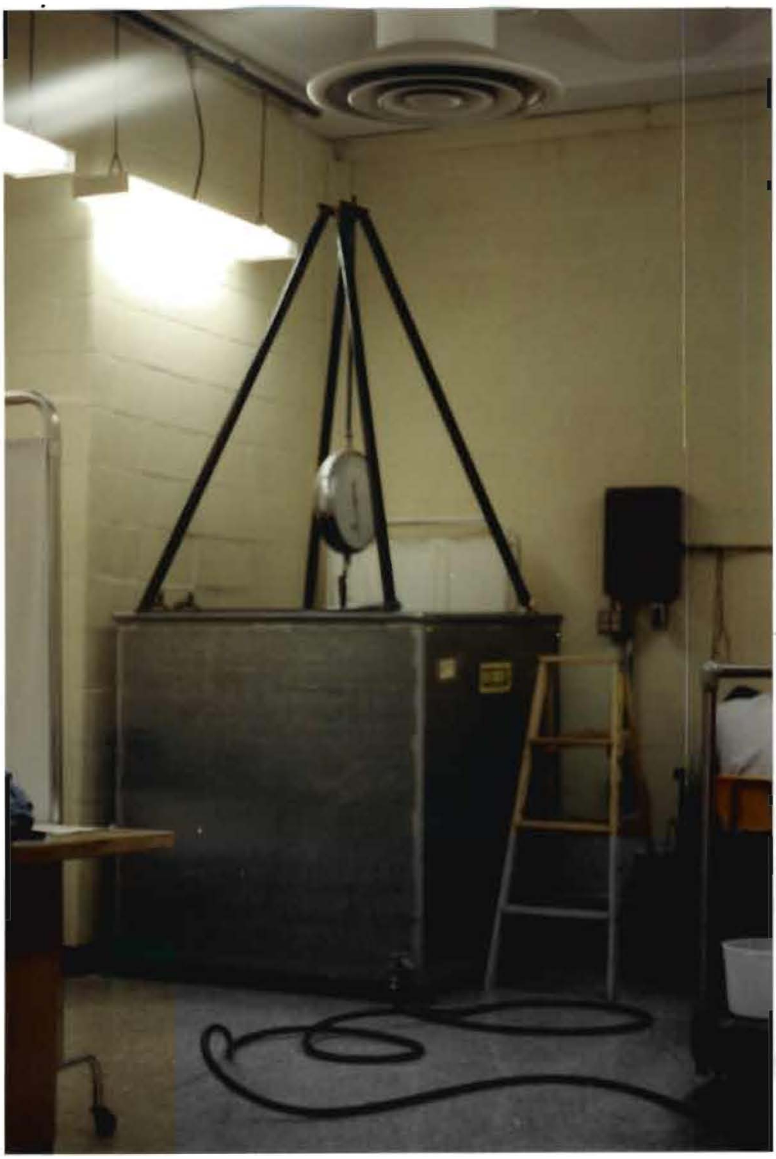
D_W: _______

TRIALS: #1 _____ #2 ______ #3 ______ #4 ______ #5 ______
#6 _____

Wt: _______

APPENDIX C

PICTURE OF THE WATER TANK



APPENDIX D

PICTURE OF A COLLINS SPIROMETER

APPENDIX E

WATER TEMPERATURE/DENSITY CHART

The Water Temperature (Tw) and water Density (Dw) relationship chart

Tw		Dw
°C	°F	$g.mL^{-1}$
0	32	0.999
4	39	1.000
22	72	0.9978
25	75	0.9971
26	79	0.9968
27	81	0.9965
28	82	0.9963
29	84	0.9960
30	86	0.9957
31	88	0.9954
32	89.5	0.9950
33	91	0.9947
34	93	0.9944
35	95	0.9941

APPENDIX F

HEIGHT/CIRCUMFERENCE VALUE CHARTS FOR MEN AND WOMEN

Table 21.2 Men's Percent Body Fat (%) Estimated from Ht (in.) and Circumference Value (Lower abdominal girth − neck girth; in.)

Circumference Value	Height (in.) 60.0	60.5	61.0	61.5	62.0	62.5	63.0	63.5	64.0	64.5
11.0:	3	2	2	2	2	1	1	1	1	1
11.5:	4	4	4	3	3	3	3	2	2	2
12.0:	6	5	5	5	5	4	4	4	4	3
12.5:	7	7	6	6	6	6	6	5	5	5
13.0:	8	8	8	8	7	7	7	7	6	6
13.5:	10	9	9	9	9	8	8	8	8	8
14.0:	11	11	10	10	10	10	10	9	9	9
14.5:	12	12	12	11	11	11	11	11	10	10
15.0:	13	13	13	13	12	12	12	12	12	11
15.5:	15	14	14	14	14	13	13	13	13	12
16.0:	16	15	15	15	15	15	14	14	14	14
16.5:	17	17	16	16	16	16	15	15	15	15
17.0:	18	18	17	17	17	17	16	16	16	16
17.5:	19	19	19	18	18	18	18	17	17	17
18.0:	20	20	20	19	19	19	19	16	18	18
18.5:	21	21	21	20	20	20	20	19	19	19
19.0:	22	22	22	21	21	21	21	20	20	20
19.5:	23	23	23	22	22	22	22	21	21	21
20.0:	24	24	23	23	23	23	22	22	22	22
20.5:	25	25	24	24	24	24	23	23	23	23
21.0:	26	26	25	25	25	25	24	24	24	24
21.5:	27	26	26	26	26	25	25	25	25	24
22.0:	28	27	27	27	27	26	26	26	26	25
22.5:	28	28	28	28	27	27	27	27	26	26
23.0:	29	29	29	29	28	28	28	28	27	27
23.5:	30	30	30	29	29	29	29	28	28	28
24.0:	31	31	30	30	30	30	29	29	29	29
24.5:	32	31	31	31	31	30	30	30	30	29
25.0:	33	32	32	32	31	31	31	31	30	30
25.5:	33	33	33	33	32	32	32	31	31	31
26.0:	34	34	34	33	33	33	32	32	32	32
26.5:	35	35	34	34	34	33	33	33	33	32
27.0:	36	35	35	35	34	34	34	34	33	33
27.5:	36	36	36	35	35	35	35	34	34	34
28.0:	37	37	36	36	36	36	35	35	35	35
28.5:	38	37	37	37	37	36	36	36	36	35
29.0:	38	38	38	38	37	37	37	37	36	36
29.5:	39	39	39	38	38	38	37	37	37	37
30.0:	40	39	39	39	39	38	38	38	38	37
30.5:	-	-	40	40	39	39	39	39	38	38
31.0:	-	-	-	-	40	40	39	39	39	39
31.5:	-	-	-	-	-	-	-	40	40	39
32.0–35.0:	-	-	-	-	-	-	-	-	-	40

Circumference Value	Height (in.) 65.0	65.5	66.0	66.5	67.0	67.5	68.0	68.5	69.0	69.5
11.0:	0	0	-	-	-	-	-	-	-	-
11.5:	2	2	1	1	1	1	1	0	0	-
12.0:	3	3	3	3	2	2	2	2	2	1
12.5:	5	4	4	4	4	4	3	3	3	3
13.0:	6	6	5	5	5	5	5	5	4	4
13.5:	7	7	7	7	6	6	6	6	6	5
14.0:	9	8	8	8	8	8	7	7	7	7
14.5:	10	10	9	9	9	9	9	8	8	8
15.0:	11	11	11	10	10	10	10	10	9	9
15.5:	12	12	12	12	11	11	11	11	11	10
16.0:	13	13	13	13	12	12	12	12	12	11
16.5:	14	14	14	14	14	13	13	13	13	13
17.0:	16	15	15	15	15	14	14	14	14	14
17.5:	17	16	16	16	16	16	15	15	15	15
18.0:	18	17	17	17	17	17	16	16	16	16

Note. From Exercise Physiology Laboratory Manual (pp. 198-204) by G. M. Adams Author, 1990, Dubuque IA: Wm. C. Brown Publishers.

Circumference Value	Height (in.) 65.0	65.5	66.0	68.5	67.0	67.5	68.0	68.5	69.0	69.5
18.5:	19	18	18	18	18	18	17	17	17	17
19.0:	20	19	19	19	19	19	18	18	18	18
19.5:	21	20	20	20	20	19	19	19	19	19
20.0:	22	21	21	21	21	20	20	20	20	20
20.5:	22	22	22	22	22	21	21	21	21	20
21.0:	23	23	23	23	22	22	22	22	22	21
21.5.	24	24	24	24	23	23	23	23	22	22
22.0:	25	25	25	24	24	24	24	24	23	23
22.5.	26	28	25	25	25	25	25	24	24	24
23.0:	27	27	26	28	26	26	25	25	25	25
23.5:	28	27	27	27	27	26	26	26	26	26
24 0:	28	28	28	28	27	27	27	27	27	26
24 5:	29	29	29	29	28	28	28	28	27	27
25.0	30	30	30	29	29	29	29	28	28	28
25.5:	31	31	30	30	30	30	29	29	29	29
26.0:	32	31	31	31	31	30	30	30	30	29
28.5:	32	32	32	32	31	31	31	31	30	30
27 0:	33	33	32	32	32	32	32	31	31	31
27 5:	34	33	33	33	33	33	32	32	32	32
28.0:	34	34	34	34	33	33	33	33	33	32
28.5:	35	35	35	34	34	34	34	33	33	33
29.0:	38	36	35	35	35	35	34	34	34	34
29.5:	36	36	36	36	35	35	35	35	35	34
30.0:	37	37	37	36	36	36	36	35	35	35
30.5:	38	38	37	37	37	37	38	36	36	36
31.0:	38	38	38	38	37	37	37	37	37	36
31 5:	39	39	39	38	38	38	38	37	37	37
32 0:	40	39	39	39	39	38	38	38	38	38
32.5:	.	.	40	40	39	39	39	39	38	38
33.0:	.	.	.	.	40	40	39	39	39	39
33.5:	.	.	.	.	.	.	.	40	40	39
34 0.	.	.	.	.	.	.	.	.	.	40
34 5:	.	.	.	.	.	.	.	.	.	.
35.0.	.	.	.	.	.	.	.	.	.	.

Circumference Value	Height (in.) 70.0	70.5	71.0	71.5	72.0	72.5	73.0	73.5	74.0	74.5
11 0:	.	.	.	.	.	.	.	.	.	.
11 5:	.	.	.	.	.	.	.	.	.	.
12.0:	1	1	1	1	0	0	0	.	.	.
12.5:	3	2	2	2	2	2	1	1	1	1
13.0:	4	4	4	3	3	3	3	3	2	2
13.5:	5	5	5	5	4	4	4	4	4	4
14 0:	7	6	5	6	5	6	5	5	5	5
14 5:	8	8	7	7	7	7	7	5	6	6
15.0:	9	9	9	8	8	8	8	8	7	7
15 5:	10	10	10	9	9	9	9	9	9	8
16 0:	11	11	11	11	10	10	10	10	10	9
16.5.	12	12	12	12	12	11	11	11	11	11
17 0:	13	13	13	13	13	12	12	12	12	12
17 5:	14	14	14	14	14	13	13	13	13	13
18.0:	15	15	15	15	15	14	14	14	14	14
18.5:	16	16	16	16	16	15	15	15	15	15
19.0:	17	17	17	17	17	16	16	16	16	16
19.5:	18	18	18	18	18	17	17	17	17	17
20.0	19	19	19	19	18	18	18	18	18	17
20.5:	20	20	20	20	19	19	19	19	19	18
21 0:	21	21	21	20	20	20	20	20	19	19
21 5.	22	22	22	21	21	21	21	21	20	20
22.0.	23	23	22	22	22	22	22	21	21	21
22 5	24	23	23	23	23	23	22	22	22	22
23.0	25	24	24	24	24	23	23	23	23	23
23 5	25	25	25	25	24	24	24	24	24	23

Circumference Value	Height (in.) 70.0	70.5	71.0	71.5	72.0	72.5	73.0	73.5	74.0	74.5
24 0	26	26	28	25	25	25	25	25	24	24
24 5	27	27	26	26	26	26	26	25	25	25
25 0.	28	27	27	27	27	27	26	26	26	26
25.5.	28	28	28	28	28	27	27	27	27	27
26 0	29	29	29	29	28	28	28	28	27	27
26.5.	30	30	29	29	29	29	29	28	28	28
27 0:	31	30	30	30	30	30	29	29	29	29
27.5.	31	31	31	31	30	30	30	30	30	29
28.0.	32	32	32	31	31	31	31	31	30	30
28.5.	33	33	32	32	32	32	31	31	31	31
29.0:	33	33	33	33	33	32	32	32	32	31
29.5:	34	34	34	33	33	33	33	33	32	32
30.0	35	35	34	34	34	34	33	33	33	33
30.5:	35	35	35	35	35	34	34	34	34	33
31.0	36	38	36	35	35	35	35	34	34	34
31.5:	37	36	36	36	36	36	35	35	35	35
32.0.	37	37	37	37	36	38	36	38	36	35
32.5.	38	38	37	37	37	37	37	36	36	36
33.0:	39	38	38	38	38	37	37	37	37	37
33.5.	39	39	39	38	38	38	38	38	37	37
34 0.	40	39	39	39	39	39	38	38	38	38
34.5	-	-	40	40	39	39	39	39	39	38
35.0.	-	-	-	-	40	40	40	39	39	39

Circumference Value	Height (in.) 75.0	75.5	76.0	76.5	77.0	77.5	78.0	78.5	79.0	79.5
11.0.	-	-	-	-	-	-	-	-	-	-
11 5:	-	-	-	-	-	-	-	-	-	-
12.0	-	-	-	-	-	-	-	-	-	-
12.5.	1	1	0	0	-	-	-	-	-	-
13.0.	2	2	2	1	1	1	1	1	1	0
13.5:	3	3	3	3	3	2	2	2	2	2
14 0.	5	4	4	4	4	4	3	3	3	3
14 5	6	6	5	5	5	5	5	5	4	4
15.0	7	7	7	6	6	6	6	6	6	5
15.5.	8	8	8	8	7	7	7	7	7	6
16.0	9	9	9	9	8	8	8	8	8	8
16.5	10	10	10	10	10	9	9	9	9	9
17.0.	11	11	11	11	11	10	10	10	10	10
17 5	12	12	12	12	12	11	11	11	11	11
18.0.	13	13	13	13	13	12	12	12	12	12
18.5.	14	14	14	14	14	13	13	13	13	13
19.0	15	15	15	15	15	14	14	14	14	14
19 5.	16	16	16	16	16	15	15	15	15	15
20 0.	17	17	17	17	16	16	16	16	16	16
20.5.	18	18	18	18	17	17	17	17	17	16
21.0:	19	19	19	18	18	18	18	18	18	17
21.5	20	20	20	19	19	19	19	19	18	18
22.0	21	21	20	20	20	20	20	19	19	19
22.5:	22	21	21	21	21	21	20	20	20	20
23.0.	22	22	22	22	22	21	21	21	21	21
23.5:	23	23	23	23	22	22	22	22	22	21
24 0.	24	24	24	23	23	23	23	23	22	22
24.5:	25	25	24	24	24	24	24	23	23	23
25.0.	28	25	25	25	25	25	24	24	24	24
25.5:	26	26	26	26	26	25	25	25	25	25
26.0:	27	27	27	26	26	26	26	26	25	25
26.5	28	28	27	27	27	27	27	26	26	26
27.0:	28	28	28	28	28	27	27	27	27	27
27 5	29	29	29	29	28	28	28	28	28	27
28.0	30	30	29	29	29	29	29	28	28	28
28.5.	31	30	30	30	30	30	29	29	29	29
29.0.	31	31	31	31	30	30	30	30	30	29

Circumference Value	75.0	75.5	76.0	76.5	77.0	77.5	78.0	78.5	79.0	79.5
					Height (in.)					
29.5:	32	32	31	31	31	31	31	30	30	30
30.0:	33	32	32	32	32	32	31	31	31	31
30.5:	33	33	33	33	32	32	32	32	32	31
31.0:	34	34	33	33	33	33	33	32	32	32
31.5:	34	34	34	34	34	33	33	33	33	33
32.0:	35	35	35	34	34	34	34	34	33	33
32.5:	36	35	35	35	35	35	34	34	34	34
33.0:	36	36	36	36	35	35	35	35	35	34
33.5:	37	37	36	36	36	36	36	35	35	35
34 0:	37	37	37	37	37	36	36	36	36	36
34.5:	38	38	38	37	37	37	37	37	36	36
35.0:	39	38	38	38	38	38	37	37	37	37
35.5:	39	39	39	39	38	38	38	38	38	37
36.0:	40	40	39	39	39	39	39	38	38	38
36.5:	-	-	40	40	39	39	39	39	39	38
37 0:	-	-	-	-	-	40	40	39	39	39
37.5:	-	-	-	-	-	-	-	40	40	40
38.0:	-	-	-	-	-	-	-	-	-	-
38.5:	-	-	-	-	-	-	-	-	-	-

Source: Hodgdon and Beckett, 1984. Courtesy of U.S. Navy

Table 21.3 Women's Percent Body Fat (%) Estimated from Ht (in.) and Circumference Value (Upper abdominal girth + hip girth − neck girth).

Circumference Value	58.0	58.5	59.0	59.5	60.0	60.5	61.0	61.5	62.0	62.5
					Height (in.)					
34 5:	1	0	-	-	-	-	-	-	-	-
35.0:	2	1	1	1	0	-	-	-	-	-
35.5:	3	2	2	2	1	1	0	0	-	-
36.0:	4	3	3	3	2	2	1	1	1	0
36 5:	5	4	4	4	3	3	2	2	2	1
37 0:	6	5	5	4	4	4	3	3	3	2
37 5:	7	6	6	5	5	5	4	4	4	3
38.0:	7	7	7	6	6	6	5	5	5	4
38.5:	8	8	8	7	7	7	6	6	5	5
39.0:	9	9	9	8	8	7	7	7	6	5
39.5:	10	10	9	9	9	8	8	8	7	7
40.0:	11	11	10	10	10	9	9	8	8	8
40.5:	12	12	11	11	10	10	10	9	9	9
41.0:	13	12	12	12	11	11	11	10	10	10
41.5:	14	13	13	13	12	12	11	11	11	10
42.0:	14	14	14	13	13	13	12	12	12	11
42.5:	15	15	15	14	14	13	13	13	12	12
43.0:	16	16	15	15	15	14	14	14	13	13
43.5:	17	17	16	16	15	15	15	14	14	14
44 0:	18	17	17	17	16	16	16	15	15	14
44 5:	19	18	18	17	17	17	16	16	16	15
45.0:	19	19	19	18	18	17	17	17	16	16
45.5:	20	20	19	19	19	18	18	18	17	17
46.0:	21	20	20	20	19	19	19	18	18	18
46.5:	22	21	21	20	20	20	19	19	19	18
47 0:	22	22	22	21	21	20	20	20	19	19
47 5:	23	23	22	22	22	21	21	21	20	20
48.0:	24	23	23	23	22	22	22	21	21	21
48.5:	25	24	24	23	23	23	22	22	22	21
49.0:	25	25	25	24	24	23	23	23	22	22
49 5:	26	26	25	25	24	24	24	23	23	23
50 0:	27	26	26	26	25	25	24	24	24	23
50.5:	27	27	27	26	26	26	25	25	24	24
51 0:	28	28	27	27	27	26	26	25	25	25

Circumference Value	58.0	58.5	59.0	59.5	60.0	60.5	61.0	61.5	62.0	62.5
	Height (in.)									
51.5:	29	28	28	28	27	27	27	26	26	25
52.0·	29	29	29	28	28	28	27	27	27	26
52.5.	30	30	29	29	29	28	28	28	27	27
53.0:	31	30	30	30	29	29	29	28	28	27
53.5	31	31	31	30	30	30	29	29	28	28
54 0	32	32	31	31	31	30	30	30	29	29
54 5.	33	32	32	32	31	31	31	30	30	29
55.0:	33	33	33	32	32	32	31	31	30	30
55.5.	34	34	33	33	33	32	32	31	31	31
56.0.	35	34	34	33	33	33	32	32	32	31
56 5·	35	35	34	34	34	33	33	33	32	32
57 0	36	35	35	35	34	34	34	33	33	33
57.5:	36	36	36	35	35	35	34	34	34	33
58.0.	37	37	36	36	36	35	35	35	34	34
58.5:	38	37	37	37	36	36	35	35	35	34
59.0.	38	38	38	37	37	36	36	36	35	35
59.5·	39	38	38	38	37	37	37	36	36	36
60.0:	39	39	39	38	38	38	37	37	37	36
60.5:	40	40	39	39	39	38	38	37	37	37
61.0	41	40	40	39	39	39	38	38	38	37
61.5.	41	41	40	40	40	39	39	39	38	38
62.0.	42	41	41	41	40	40	40	39	39	38
62.5:	42	42	42	41	41	40	40	40	39	39
63.0.	43	42	42	42	41	41	41	40	40	40
63.5.	43	43	43	42	42	42	41	41	40	40
64.0.	44	44	43	43	42	42	42	41	41	41
64 5:	45	44	44	43	43	43	42	42	42	41
65.0	-	45	44	44	44	43	43	42	42	42
65.5:	-	-	45	44	44	44	43	43	43	42
66.0:	-	-	-	-	45	44	44	44	43	43
66.5·	-	-	-	-	-	45	44	44	44	43
67.0:	-	-	-	-	-	-	45	45	44	44
67.5	-	-	-	-	-	-	-	-	45	44
68.0–75.5:	-	-	-	-	-	-	-	-	-	45

Circumference Value	63.0	63.5	64.0	64.5	65.0	65.5	66.0	66.5	67.0	67.5
	Height (in.)									
34 5.	-	-	-	-	-	-	-	-	-	-
35.0·	-	-	-	-	-	-	-	-	-	-
35.5·	-	-	-	-	-	-	-	-	-	-
36.0:	0	-	-	-	-	-	-	-	-	-
36.5:	1	1	0	-	-	-	-	-	-	-
37 0.	2	2	1	1	1	0	-	-	-	-
37.5:	3	3	2	2	2	1	1	1	0	-
38.0:	4	3	3	3	2	2	2	1	1	1
38.5:	5	4	4	4	3	3	3	2	2	2
39.0:	6	5	5	5	4	4	4	3	3	3
39.5:	7	6	6	6	5	5	5	4	4	4
40 0:	7	7	7	6	6	6	5	5	5	4
40.5:	8	8	8	7	7	7	6	6	6	5
41.0·	9	9	8	8	8	7	7	7	6	6
41.5·	10	10	9	9	9	8	8	8	7	7
42.0:	11	10	10	10	9	9	9	8	8	8
42.5.	12	11	11	11	10	10	10	9	9	9
43.0:	12	12	12	11	11	11	10	10	10	9
43.5.	13	13	13	12	12	12	11	11	11	10
44 0:	14	14	13	13	13	12	12	12	11	11
44.5.	15	15	14	14	14	13	13	13	12	12
45.0.	16	15	15	15	14	14	14	13	13	13
45.5:	16	16	16	15	15	15	14	14	14	13
46.0·	17	17	17	16	16	16	15	15	15	14
46.5	18	18	17	17	17	16	16	16	15	15

Circumference Value	Height (in.) 63.0	63.5	64.0	64.5	65.0	65.5	66.0	66.5	67.0	67.5
47.0:	19	18	18	18	17	17	17	16	16	16
47.5:	19	19	19	18	18	18	17	17	17	16
48.0:	20	20	20	19	19	18	18	18	18	17
48.5:	21	21	20	20	20	19	19	19	18	18
49.0:	22	21	21	21	20	20	20	19	19	19
49.5:	22	22	22	21	21	21	20	20	20	19
50.0:	23	23	22	22	22	21	21	21	20	20
50.5:	24	23	23	23	22	22	22	21	21	21
51.0:	24	24	24	23	23	23	22	22	22	21
51.5:	25	25	24	24	24	23	23	23	22	22
52.0:	25	25	25	25	24	24	24	23	23	23
52.5:	26	26	26	25	25	25	24	24	24	23
53.0:	27	27	26	26	26	25	25	25	24	24
53.5:	28	27	27	27	26	26	26	25	25	25
54.0:	28	28	28	27	27	27	26	26	26	25
54.5:	29	29	28	28	28	27	27	27	26	26
55.0:	30	29	29	29	28	28	28	27	27	27
55.5:	30	30	30	29	29	29	28	28	28	27
56.0:	31	31	30	30	30	29	29	29	28	28
56.5:	32	31	31	31	30	30	30	29	29	29
57.0:	32	32	32	31	31	31	30	30	30	29
57.5:	33	32	32	32	31	31	31	30	30	30
58.0:	33	33	33	32	32	32	31	31	31	30
58.5:	34	34	33	33	33	32	32	32	31	31
59.0:	35	34	34	34	33	33	33	32	32	32
59.5:	35	35	35	34	34	34	33	33	33	32
60.0:	36	35	35	35	34	34	34	33	33	33
60.5:	36	36	36	35	35	35	34	34	34	33
61.0:	37	37	36	36	36	35	35	35	34	34
61.5:	38	37	37	37	36	36	36	35	35	35
62.0:	38	38	37	37	37	36	36	36	35	35
62.5:	39	38	38	38	37	37	37	36	36	36
63.0:	39	39	39	38	38	38	37	37	37	36
63.5:	40	39	39	39	38	38	38	37	37	37
64.0:	40	40	40	39	39	39	38	38	38	37
64.5:	41	41	40	40	40	39	39	39	38	38
65.0:	41	41	41	40	40	40	39	39	39	38
65.5:	42	42	41	41	41	40	40	40	39	39
66.0:	43	42	42	41	41	41	40	40	40	39
66.5:	43	43	42	42	42	41	41	41	40	40
67.0:	44	43	43	43	42	42	42	41	41	41
67.5:	44	44	43	43	43	42	42	42	41	41
68.0:	45	44	44	44	43	43	43	42	42	42
68.5:	.	45	44	44	44	43	43	43	42	42
69.0:	.	.	45	45	44	44	44	43	43	43
69.5:	.	.	.	.	45	44	44	44	43	43
70.0:	.	.	.	.	.	45	45	44	44	44
70.5:	.	.	.	.	.	.	.	45	44	44
71.0–75.5:	.	.	.	.	.	.	.	.	45	45

Circumference Value	Height (in.) 68.0	68.5	69.0	69.5	70.0	70.5	71.0	71.5	72.0	72.5
34.5:	.	.	.	.	.	.	.	.		.
35.0:	.	.	.	.	.	.	.	.	.	.
35.5:	.	.	.	.	.	.	.	.	.	.
36.0:	.	.	.	.	.	.	.	.	.	.
36.5:	.	.	.	.	.	.	.	.	.	.
37.0:	.	.	.	.	.	.	.	.	.	
37.5:	.	.	.	.	.	.	.	.	.	.
38.0:	0	0	.	.	.	.	.	.	.	.
38.5:	1	1	1	0	0	.	.	.	.	.
39.0:	2	2	2	1	1	1	0	0	.	.
39.5:	3	3	3	2	2	2	1	1	1	0

Circumference Value	68.0	68.5	69.0	69.5	70.0	70.5	71.0	71.5	72.0	72.5
	Height (in.)									
40.0:	4	4	3	3	3	3	2	2	2	1
40.5:	5	5	4	4	4	3	3	3	2	2
41.0:	6	5	5	5	5	4	4	4	3	3
41.5:	7	6	6	6	5	5	5	4	4	4
42.0:	8	7	7	7	6	6	6	5	5	5
42.5:	8	8	8	7	7	7	6	6	6	6
43.0:	9	9	9	8	8	8	7	7	7	6
43.5:	10	10	9	9	9	8	8	8	7	7
44.0:	11	10	10	10	9	9	9	9	8	8
44.5:	12	11	11	11	10	10	10	9	9	9
45.0:	12	12	12	11	11	11	10	10	10	10
45.5:	13	13	12	12	12	12	11	11	11	10
46.0:	14	14	13	13	13	12	12	12	11	11
46.5:	15	14	14	14	13	13	13	12	12	12
47.0:	15	15	15	14	14	14	13	13	13	13
47.5:	16	16	15	15	15	15	14	14	14	13
48.0:	17	17	16	16	16	15	15	15	14	14
48.5:	18	17	17	17	16	16	16	15	15	15
49.0:	18	18	18	17	17	17	16	16	16	15
49.5:	19	19	18	18	18	17	17	17	17	16
50.0:	20	19	19	19	18	18	18	18	17	17
50.5:	20	20	20	19	19	19	19	18	18	18
51.0:	21	21	20	20	20	20	19	19	19	18
51.5:	22	21	21	21	21	20	20	20	19	19
52.0:	22	22	22	22	21	21	21	20	20	20
52.5:	23	23	22	22	22	22	21	21	21	20
53.0:	24	23	23	23	23	22	22	22	21	21
53.5:	24	24	24	23	23	23	23	22	22	22
54.0:	25	25	24	24	24	24	23	23	23	22
54.5:	26	25	25	25	24	24	24	24	23	23
55.0:	26	26	26	25	25	25	24	24	24	24
55.5:	27	27	26	26	26	25	25	25	25	24
56.0:	28	27	27	27	26	26	26	25	25	25
56.5:	28	28	28	27	27	27	26	26	26	25
57.0:	29	29	28	28	28	27	27	27	26	26
57.5:	30	29	29	29	28	28	28	27	27	27
58.0:	30	30	29	29	29	29	28	28	28	27
58.5:	31	30	30	30	29	29	29	29	28	28
59.0:	31	31	31	30	30	30	29	29	29	28
59.5:	32	32	31	31	31	30	30	30	29	29
60.0:	32	32	32	32	31	31	31	30	30	30
60.5:	33	33	32	32	32	31	31	31	31	30
61.0:	34	33	33	33	32	32	32	31	31	31
61.5:	34	34	34	33	33	33	32	32	32	31
62.0:	35	34	34	34	34	33	33	33	32	32
62.5:	35	35	35	34	34	34	33	33	33	33
63.0:	36	36	35	35	35	34	34	34	33	33
63.5:	36	36	36	35	35	35	35	34	34	34
64.0:	37	37	36	36	36	35	35	35	35	34
64.5:	38	37	37	37	36	36	36	35	35	35
65.0:	38	38	37	37	37	37	36	36	36	35
65.5:	39	38	38	38	37	37	37	36	36	36
66.0:	39	39	39	38	38	38	37	37	37	36
66.5:	40	39	39	39	38	38	38	37	37	37
67.0:	40	40	40	39	39	39	38	38	38	37
67.5:	41	40	40	40	39	39	39	39	38	38
68.0:	41	41	41	40	40	40	39	39	39	38
68.5:	42	41	41	41	40	40	40	40	39	39
69.0:	42	42	42	41	41	41	40	40	40	39
69.5:	43	42	42	42	42	41	41	41	40	40
70.0:	43	43	43	42	42	42	41	41	41	40
70.5:	44	43	43	43	43	42	42	42	41	41
71.0:	44	44	44	43	43	43	42	42	42	41

APPENDIX G

RAW DATA FOR BOTH GROUPS (% of fat)

Raw Data for Group 1 (Non-weight Trained)

				% of Fat	
Name	No	Sex	Hydrostat	Skinfold	Girth
20	1	m	10	6.6	12.2
15	2	m	10.9	6.6	10.5
19	3	m	10.9	7.1	11.3
37	4	m	11.3	9.6	13.5
18	5	m	11.3	7.9	13.5
16	6	m	12.6	5	8.3
6	7	m	13.9	4.1	5.4
17	8	m	16	8.3	12.6
33	9	m	16.5	6.6	16.1
4	10	m	16.5	12.2	14.8
40	11	m	17.4	10	12.6
41	12	m	17.9	20.1	21
26	13	m	18.3	9.6	12.6
9	14	m	21	12.6	20.1
39	15	m	21.4	16.1	16.1
28	16	m	21.4	19	22.3
7	17	m	21.4	10	9.6
3	18	m	25	18.3	21.4
2	19	m	26	23.7	25.5
21	20	m	27.3	24.6	29.2
1	21	m	30.6	22.8	25.5
38	22	m	31	20.5	27.8
23	23	f	16.5	16.5	24.6
29	24	f	22.3	27.8	24.6
30	25	f	22.8	22.8	26.4
14	26	f	22.8	20.5	17.9
25	27	f	22.8	20.5	24.1
34	28	f	23.2	27.3	24.6

42	29	f	23.2	23.7	23.7
31	30	f	23.7	19.3	23.7
32	31	f	24.1	24.6	20.1
13	32	f	25	13.5	17.9
24	33	f	25.5	26.4	24.6
12	34	f	26.4	28.3	24.1
8	35	f	26.4	21.4	18.3
11	36	f	26.9	25	30.1
27	37	f	27.8	24.6	27.3
35	38	f	28.3	28.3	30.1
22	39	f	28.7	27.8	24.1
36	40	f	28.7	28.3	24.6
5	41	f	28.7	31.5	31.5
10	42	f	32.4	27.8	28.3

Raw Data for Group 2 (Weight Trained)

Name	No	Sex	Hydrostatic	Skinfold	Girth
5	1	M	7.1	5.4	13.1
2	2	M	8.8	6.2	13.5
3	3	M	9.2	5.8	10.9
7	4	M	10.9	8.3	17.4
15	5	M	11.3	5.4	10.9
9	6	M	13.9	6.6	15.7
14	7	M	13.9	3.3	10
12	8	M	16.5	11.8	15.7
13	9	M	16.5	10.9	10.9
10	10	M	16.5	10.9	21.9
4	11	M	17	17	13.9
1	12	M	17.9	12.6	19.6
6	13	M	18.3	14.4	24
16	14	M	18.3	13.9	19.2
17	15	M	20.1	13.9	19.2
11	16	M	24.4	10.9	22.3
8	17	M	27.8	20.1	25.5

I, George Savourdos, hereby submit this thesis to Emporia State University as partial fulfillment of the requirements for an advanced degree. I agree that the Library of the University may make it available for use in accordance with its regulations governing materials of this type. I further agree that quoting, photocopying, or other reproduction of this document is allowed for private study, scholarship (including teaching) and research of a nonprofit nature. No copying which involves potential gain will be allowed without written permission of the author.

Signature of Author

12-20-93
Date

A Comparison of Two Body Composition
Title of Thesis

Tests: The 3-Site Skinfolds and the

2-3-Girth Measurements

Signature of Graduate Office Staff Member

12-20-93
Date Received